TITLE

Microphone system

AREA OF THE INVENTION

The invention relates to the area of hearing devices and assistive listening devices, which are used by hearing-impaired individuals. More specifically the invention relates to the field of microphone arrays used in connection with or implemented in such hearing devices and/or assistive listening devices in order to achieve an increased directivity in a particular listening situation.

BACKGROUND OF THE INVENTION

It is well known how to provide directivity by means of microphone arrays disposed either in a hearing aid or in a separate device connected to a hearing aid. Directivity should in this context be understood as increased sensitivity to sound received from a certain direction relative to other directions.

These previously known devices and the methods associated with them do provide a certain element of directivity to the individual using the system, thereby providing help to this individual in difficult listening situations, e.g. noisy listening situations, by providing an opportunity to focus on a desired target and to reduce the input of surrounding noise signals. However since the previously known devices, due to size issues, have been limited to achieve the increased directivity for relatively high frequencies the individual has not been able to obtain the same benefit in the low frequency range and hence there have so far been a significant lack of information from the desired signal to the individual. This problem is especially serious for hearing-impaired individuals who, by virtue of their pathology, must rely mainly on low- frequency information for speech perception.

Due to this fact the objectives of the present invention are to provide a method, a microphone array, a hearing system, as well as a hearing aid and a microphone unit that

besides the high-frequency directivity will be able to provide the desired low-frequency benefit in the same listening situation.

SUMMARY OF THE INVENTION

The primary objective is according to the invention achieved by means of the method defined in claim 1.

By means of such method the directivity in the low frequency area may be increased significantly without the need of increasing the size of the physical equipment correspondingly.

The second objective is achieved by means of the microphone array as defined in claim 5.

As explained above such microphone array may improve the directivity in the lower frequency area.

The third objective is achieved by means of the hearing system as defined in claim 10. Such hearing aid system implements the fundamentals of the above- mentioned principles in a hearing aid and due to the use of the existing microphone a significant synergy is achieved.

The fourth objective is achieved by means of a hearing aid as defined in claim 12. This hearing aid forms part of a hearing system as described above.

The fifth objective is achieved by means of a microphone unit as defined in claim 14. This microphone unit forms part of a hearing system as described above.

Advantageous embodiments are defined in the sub claims referring to the above-mentioned main claims.

More details will become apparent in the following description of preferred embodiments, with reference to the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic drawing depicting a system according to the invention;

FIG. 2 is a schematic drawing depicting a hearing system according to the invention;

FIG. 3 is a schematic drawing depicting a microphone array and further depicting the principles of increasing the microphone distance;

FIG. 4 shows simulated attenuation at different angles in connection with a known system;

FIG. 5 shows simulated attenuation at different angles in connection with a first system according to the invention;

FIG. 6 shows simulated attenuation at different angles in connection with a second system according to the invention.

DESCRIPTION OF A PREFERRED EMBODIMENT

From FIG. 1 and FIG. 2 a system according to the invention appears. The system comprises a hearing aid and a separate microphone unit. FIG. 1 shows schematically the connection of the various elements and FIG. 2 shows schematically the embedded solution as a portable microphone unit 11 and a hearing aid 10.

The hearing aid 10 comprises a signal path with a microphone 4, a preamplification unit 5, a processing unit 8 and an output transducer 9. In addition to this the hearing aid comprises a receiver 7 for receiving wireless transmitted signals. Circuitry is provided for conveying the received signals to the processing unit.

The separate microphone unit 11 comprises three microphones 1,2,3 with individual preamplifiers A,B,C and a transmitter 6 for wireless transmission of microphone signals to the hearing aid. A processor D is present for local processing of microphone signals.

FIG. 3 depicts a system involving a microphone system comprising two units, which are interconnected. Each of the two units comprises at least one microphone; in the example

shown three microphones 1,2,3 are mounted in a first unit and one microphone 4 in a second unit. The two units may be displaced relative to each other thereby increasing or decreasing the distance between the microphones in the first and in the second unit. The two units are here shown sliding along sliding rods 12. This is shown more clearly in FIG. 3, where two different positions with the distances D1 and D2 between the units are shown. When increasing the distance between the two units and hence the microphones an increased directivity for lower frequencies may be obtained. The distance between the microphones is important in relation to the actual frequency area that is targeted for increased directivity. Lower frequencies require longer distances between the microphones due to the longer wavelength of the lower-frequency sound signals.

When having the two units interconnected it may be possible to have a sensor or the like to determine the actual position of the second unit relative to the first and hence have accurate information on the distance, which may be important to the directivity processing.

FIG. 4, 5 and 6 show attenuation of signals at different angles. The curve shown in FIG. 4 shows the simulated attenuation of incoming signals in a usual microphone array. In the curve shown in FIG. 5 the off-axis sensitivity is shown for a system according to the invention, where an additional microphone has been placed at a distance from the array used in connection with the previous simulation, the result of which is shown in FIG. 4. It becomes apparent from FIG. 5 that the off-axis low-frequency attenuation is greater (i.e., sensitivity is lower) in this system according to the invention. In the curve shown in FIG. 6 the attenuation is shown for a system according to the invention, where an additional microphone has been placed at a distance from the array used in connection with the previous simulation, the result of which is shown in FIG. 4. In addition to this, low-pass filtering of the signal arising from the additional microphone has been implemented. It becomes apparent that the off-axis low-frequency attenuation has been further improved, without compromising the off-axis attenuation in the higher frequencies, i.e. even greater directivity is achieved, in this system according to the invention.

When obtaining the directivity from the microphone signals simple well known sum-delay principles may be utilized, however any other principle may be used in the directivity processing.